

# RF Power Field Effect Transistors

## N-Channel Enhancement-Mode Lateral MOSFETs

Designed for CDMA base station applications with frequencies from 2110 to 2170 MHz. Suitable for CDMA and multicarrier amplifier applications. To be used in Class AB and Class C for PCN-PCS/cellular radio and WLL applications.

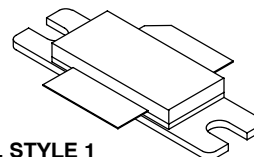
- Typical Single-Carrier W-CDMA Performance:  $V_{DD} = 28$  Volts,  $I_{DQ} = 1100$  mA,  $P_{out} = 33$  Watts Avg.,  $f = 2167.5$  MHz, IQ Magnitude Clipping, Channel Bandwidth = 3.84 MHz, Input Signal PAR = 7.5 dB @ 0.01% Probability on CCDF.  
Power Gain — 17.3 dB  
Drain Efficiency — 32.5%  
Device Output Signal PAR — 6.1 dB @ 0.01% Probability on CCDF  
ACPR @ 5 MHz Offset — -38 dBc in 3.84 MHz Channel Bandwidth
- Capable of Handling 10:1 VSWR, @ 32 Vdc, 2140 MHz, 110 Watts CW Peak Tuned Output Power
- $P_{out}$  @ 1 dB Compression Point  $\approx$  110 Watts CW

### Features

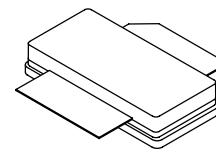
- 100% PAR Tested for Guaranteed Output Power Capability
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Internally Matched for Ease of Use
- Integrated ESD Protection
- Greater Negative Gate-Source Voltage Range for Improved Class C Operation
- Designed for Digital Predistortion Error Correction Systems
- RoHS Compliant
- In Tape and Reel. R3 Suffix = 250 Units, 56 mm Tape Width, 13 inch Reel.

**MRF7S21110HR3**  
**MRF7S21110HSR3**

**2110-2170 MHz, 33 W AVG., 28 V**  
**SINGLE W-CDMA**  
**LATERAL N-CHANNEL**  
**RF POWER MOSFETs**



**CASE 465-06, STYLE 1**  
**NI-780**  
**MRF7S21110HR3**



**CASE 465A-06, STYLE 1**  
**NI-780S**  
**MRF7S21110HSR3**

**Table 1. Maximum Ratings**

Rating	Symbol	Value	Unit
Drain-Source Voltage	$V_{DSS}$	-0.5, +65	Vdc
Gate-Source Voltage	$V_{GS}$	-6.0, +10	Vdc
Operating Voltage	$V_{DD}$	32, +0	Vdc
Storage Temperature Range	$T_{stg}$	- 65 to +150	°C
Case Operating Temperature	$T_C$	150	°C
Operating Junction Temperature (1,2)	$T_J$	225	°C

**Table 2. Thermal Characteristics**

Characteristic	Symbol	Value (2,3)	Unit
Thermal Resistance, Junction to Case Case Temperature 80°C, 109 W CW Case Temperature 78°C, 33 W CW	$R_{\theta JC}$	0.37 0.41	°C/W

1. Continuous use at maximum temperature will affect MTTF.
2. MTTF calculator available at <http://www.freescale.com/rf>. Select Software & Tools/Development Tools/Calculators to access MTTF calculators by product.
3. Refer to AN1955, *Thermal Measurement Methodology of RF Power Amplifiers*. Go to <http://www.freescale.com/rf>. Select Documentation/Application Notes - AN1955.

**Table 3. ESD Protection Characteristics**

Test Methodology	Class
Human Body Model (per JESD22-A114)	1B (Minimum)
Machine Model (per EIA/JESD22-A115)	A (Minimum)
Charge Device Model (per JESD22-C101)	IV (Minimum)

**Table 4. Electrical Characteristics** ( $T_A = 25^\circ\text{C}$  unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
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**Off Characteristics**

Zero Gate Voltage Drain Leakage Current ( $V_{DS} = 65\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc}$ )	$I_{DSS}$	—	—	10	$\mu\text{Adc}$
Zero Gate Voltage Drain Leakage Current ( $V_{DS} = 28\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc}$ )	$I_{DSS}$	—	—	1	$\mu\text{Adc}$
Gate-Source Leakage Current ( $V_{GS} = 5\text{ Vdc}$ , $V_{DS} = 0\text{ Vdc}$ )	$I_{GSS}$	—	—	1	$\mu\text{Adc}$

**On Characteristics**

Gate Threshold Voltage ( $V_{DS} = 10\text{ Vdc}$ , $I_D = 270\ \mu\text{Adc}$ )	$V_{GS(th)}$	1.2	2	2.7	Vdc
Gate Quiescent Voltage ( $V_{DD} = 28\text{ Vdc}$ , $I_D = 1100\ \text{mAdc}$ , Measured in Functional Test)	$V_{GS(Q)}$	2	2.7	3.5	Vdc
Drain-Source On-Voltage ( $V_{GS} = 10\text{ Vdc}$ , $I_D = 2.7\ \text{Adc}$ )	$V_{DS(on)}$	0.05	0.1	0.3	Vdc

**Dynamic Characteristics (1)**

Reverse Transfer Capacitance ( $V_{DS} = 28\text{ Vdc} \pm 30\ \text{mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$ )	$C_{rss}$	—	7.95	—	pF
Output Equivalent Capacitance ( $V_{DS} = 28\text{ Vdc} \pm 30\ \text{mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$ )	$C_{oss}$	—	613	—	pF
Input Capacitance ( $V_{DS} = 28\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc} \pm 30\ \text{mV(rms)ac}$ @ 1 MHz)	$C_{iss}$	—	232	—	pF

**Functional Tests** (In Freescale Test Fixture, 50 ohm system)  $V_{DD} = 28\text{ Vdc}$ ,  $I_{DQ} = 1100\ \text{mA}$ ,  $P_{out} = 33\ \text{W Avg.}$ ,  $f = 2167.5\ \text{MHz}$ , Single-Carrier W-CDMA, IQ Magnitude Clipping, Input Signal PAR = 7.5 dB @ 0.01% Probability on CCDF. ACPR measured in 3.84 MHz Channel Bandwidth @  $\pm 5\ \text{MHz}$  Offset.

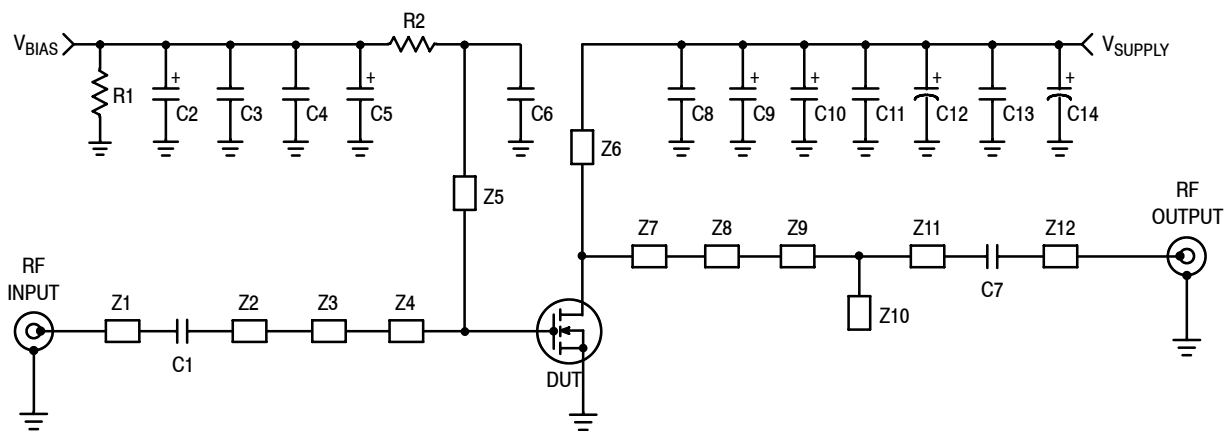
Power Gain	$G_{ps}$	16.5	17.3	19.5	dB
Drain Efficiency	$\eta_D$	31	32.5	39	%
Output Peak-to-Average Ratio @ 0.01% Probability on CCDF	PAR	5.7	6.1	6.5	dB
Adjacent Channel Power Ratio	ACPR	-48	-38	-35	dBc
Input Return Loss	IRL	—	-15	—	dB

1. Part internally matched both on input and output.

(continued)

**Table 4. Electrical Characteristics** ( $T_A = 25^\circ\text{C}$  unless otherwise noted) (continued)

Characteristic	Symbol	Min	Typ	Max	Unit
<b>Typical Performances</b> (In Freescale Test Fixture, 50 ohm system) $V_{DD} = 28\text{ Vdc}$ , $I_{DQ} = 1100\text{ mA}$ , 2110–2170 MHz Bandwidth					
Video Bandwidth @ 90 W PEP $P_{out}$ where $IM3 = -30\text{ dBc}$ (Tone Spacing from 100 kHz to VBW) $\Delta IMD3 = IMD3 @ \text{VBW frequency} - IMD3 @ 100\text{ kHz} < 1\text{ dBc}$ (both sidebands)	VBW	—	10	—	MHz
Gain Flatness in 60 MHz Bandwidth @ $P_{out} = 33\text{ W Avg.}$	$G_F$	—	0.325	—	dB
Average Deviation from Linear Phase in 60 MHz Bandwidth @ $P_{out} = 110\text{ W CW}$	$\Phi$	—	0.772	—	°
Average Group Delay @ $P_{out} = 110\text{ W CW}$ , $f = 2140\text{ MHz}$	Delay	—	1.9	—	ns
Part-to-Part Insertion Phase Variation @ $P_{out} = 110\text{ W CW}$ , $f = 2140\text{ MHz}$ , Six Sigma Window	$\Delta\Phi$	—	39.7	—	°
Gain Variation over Temperature ( $-30^\circ\text{C}$ to $+85^\circ\text{C}$ )	$\Delta G$	—	0.011	—	dB/°C
Output Power Variation over Temperature ( $-30^\circ\text{C}$ to $+85^\circ\text{C}$ )	$\Delta P_{1dB}$	—	0.028	—	dB/°C



Z1	1.280" x 0.084" Microstrip	Z8	0.370" x 0.201" Microstrip
Z2	0.856" x 0.084" Microstrip	Z9	0.386" x 0.084" Microstrip
Z3	0.240" x 0.280" Microstrip	Z10	0.196" x 0.242" Microstrip
Z4	0.420" x 0.880" Microstrip	Z11	0.105" x 0.084" Microstrip
Z5	0.950" x 0.0395" Microstrip	Z12	1.267" x 0.084" Microstrip
Z6	0.526" x 0.0940" Microstrip	PCB	Arlon CuClad 250GX-0300-55-22, 0.030", $\epsilon_r = 2.55$
Z7	0.480" x 1.050" Microstrip		

**Figure 1. MRF7S21110HR3(HSR3) Test Circuit Schematic**

**Table 5. MRF7S21110HR3(HSR3) Test Circuit Component Designations and Values**

Part	Description	Part Number	Manufacturer
C1	15 pF, Chip Capacitor	ATC100B150JT500XT	ATC
C2	47 $\mu$ F, 16 V Tantalum Capacitor	T491D476K016AT	Kemet
C3	8.2 pF, Chip Capacitor	ATC100B8R2CT500XT	ATC
C4, C13	2.2 $\mu$ F, 50 V Chip Capacitors	C1825C225J5RAC	Kemet
C5	1 $\mu$ F, 50 V Tantalum Capacitor	T491C105K050AT	Kemet
C6	5.1 pF Chip Capacitor	ATC100B5R1CT500XT	ATC
C7	16 pF Chip Capacitor	ATC100B160JT500XT	ATC
C8	6.8 pF Chip Capacitor	ATC100B6R8BT500XT	ATC
C9, C10	22 $\mu$ F, 35 V Tantalum Capacitors	T491X226K035AT	Kemet
C11	0.1 $\mu$ F Chip Capacitor	C1206C104K5RAC	Kemet
C12	100 $\mu$ F, 50 V Electrolytic Capacitor	MCR63V477M13X26	Multicomp
C14	470 $\mu$ F, 63 V Electrolytic Capacitor	MCR50V107M8X11	Multicomp
R1	1 K $\Omega$ , 1/4 W Chip Resistor	CRCW12061001FKEA	Vishay
R2	10 $\Omega$ , 1/3 W Chip Resistor	CRCW121010R0FKEA	Vishay

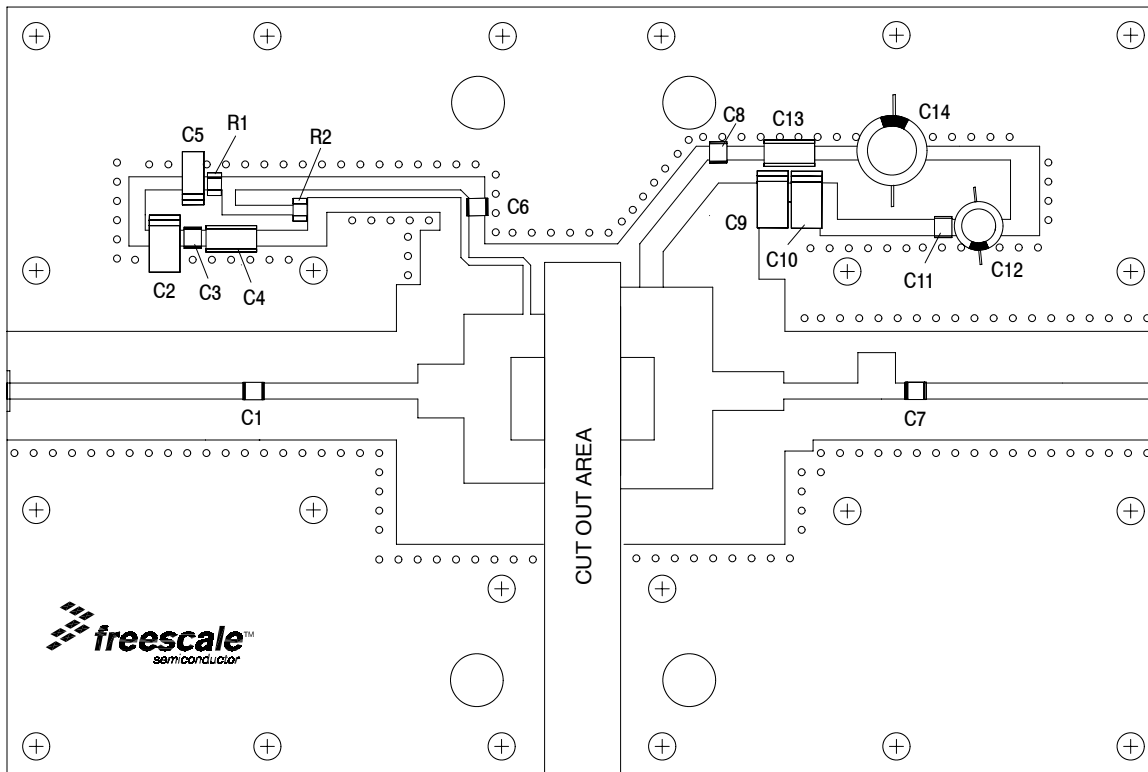
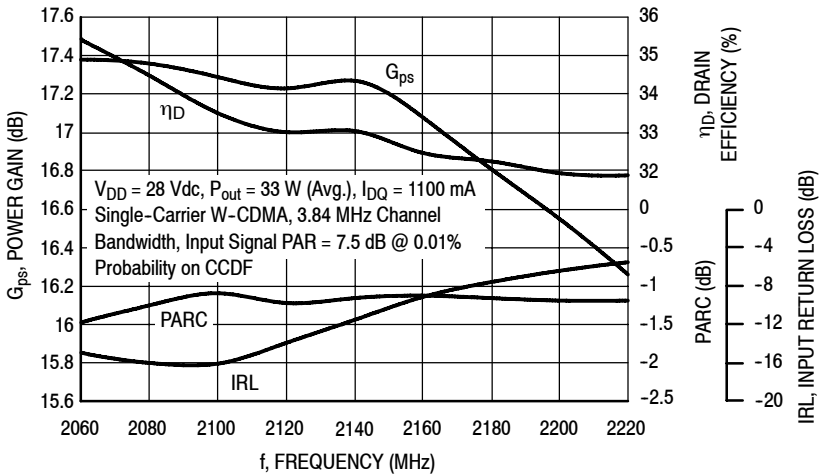
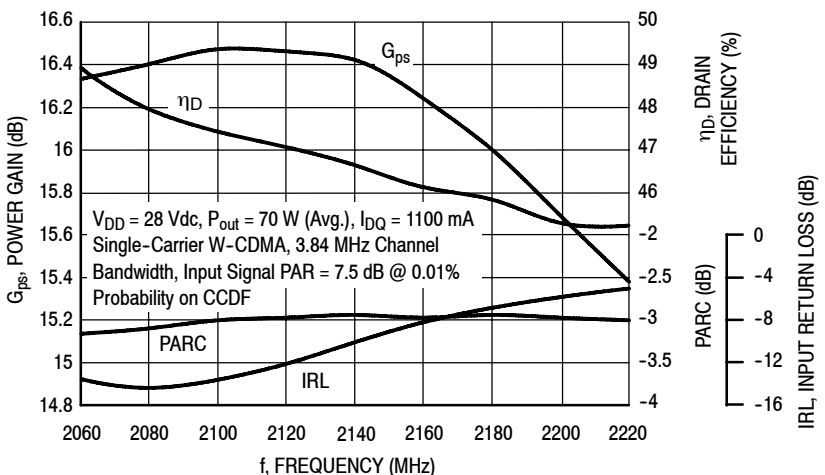


Figure 2. MRF7S2110HR3(HSR3) Test Circuit Component Layout

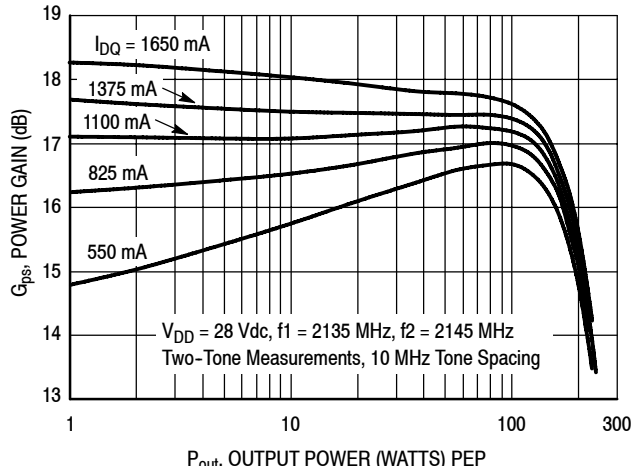
### TYPICAL CHARACTERISTICS



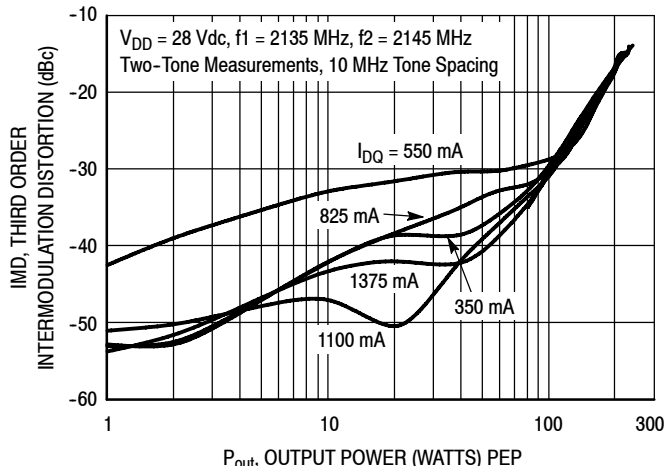
**Figure 3. Output Peak-to-Average Ratio Compression (PARC) Broadband Performance @  $P_{out} = 33$  Watts Avg.**



**Figure 4. Output Peak-to-Average Ratio Compression (PARC) Broadband Performance @  $P_{out} = 70$  Watts Avg.**

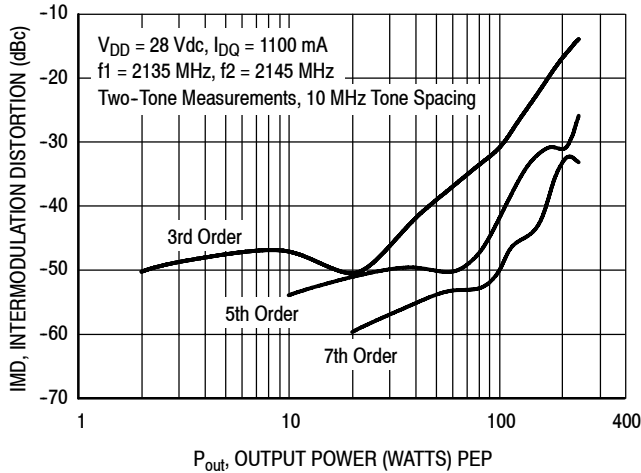


**Figure 5. Two-Tone Power Gain versus Output Power**

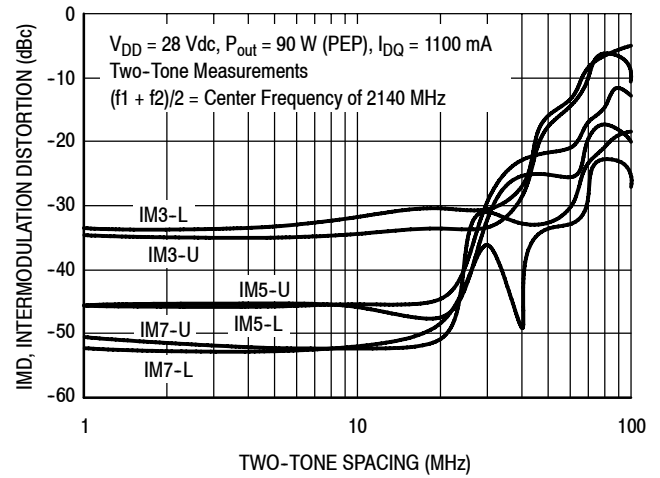


**Figure 6. Third Order Intermodulation Distortion versus Output Power**

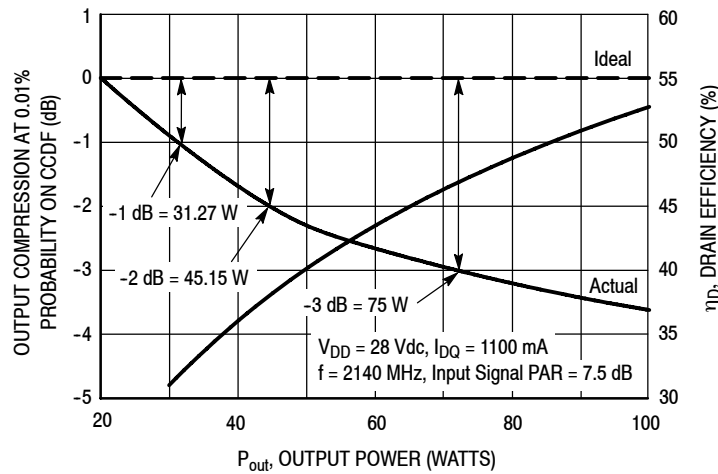
## TYPICAL CHARACTERISTICS



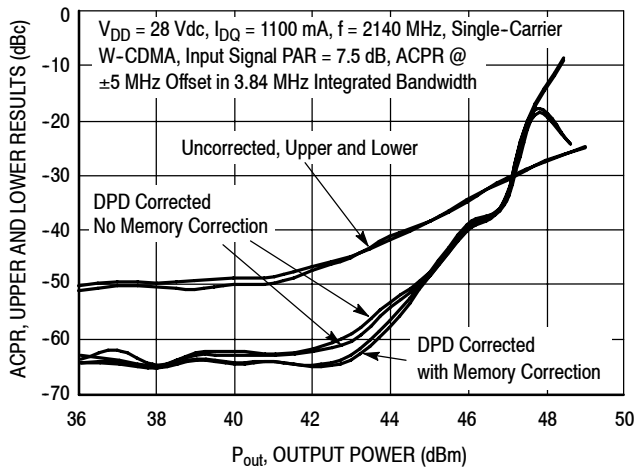
**Figure 7. Intermodulation Distortion Products versus Output Power**



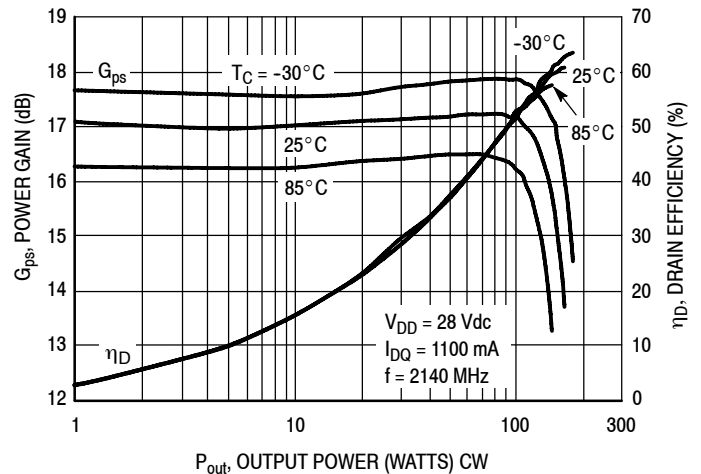
**Figure 8. Intermodulation Distortion Products versus Tone Spacing**



**Figure 9. Output Peak-to-Average Ratio Compression (PARC) versus Output Power**



**Figure 10. Digital Predistortion Correction versus ACPR and Output Power**



**Figure 11. Power Gain and Drain Efficiency versus CW Output Power**

### TYPICAL CHARACTERISTICS

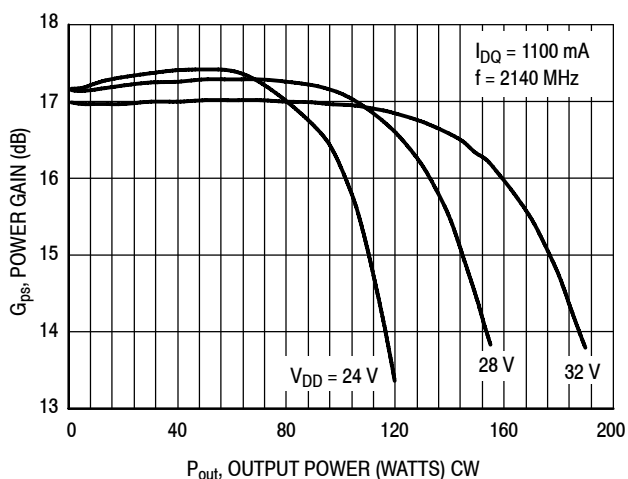


Figure 12. Power Gain versus Output Power

### W-CDMA TEST SIGNAL

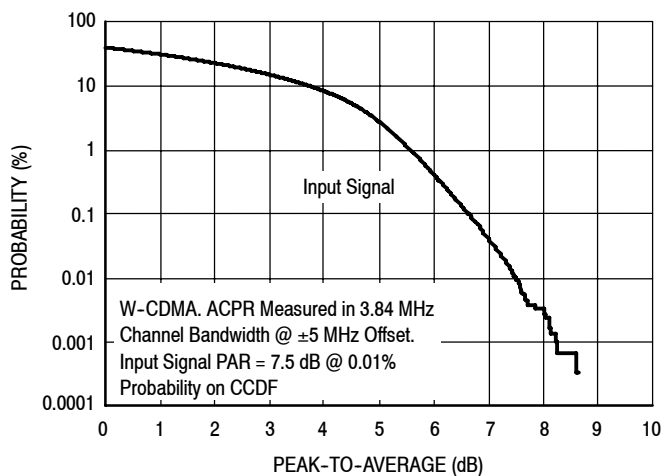


Figure 13. CCDF W-CDMA IQ Magnitude Clipping, Single-Carrier Test Signal

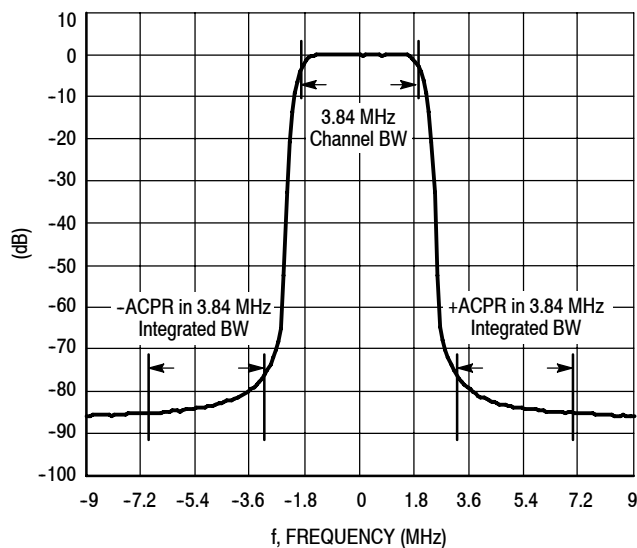
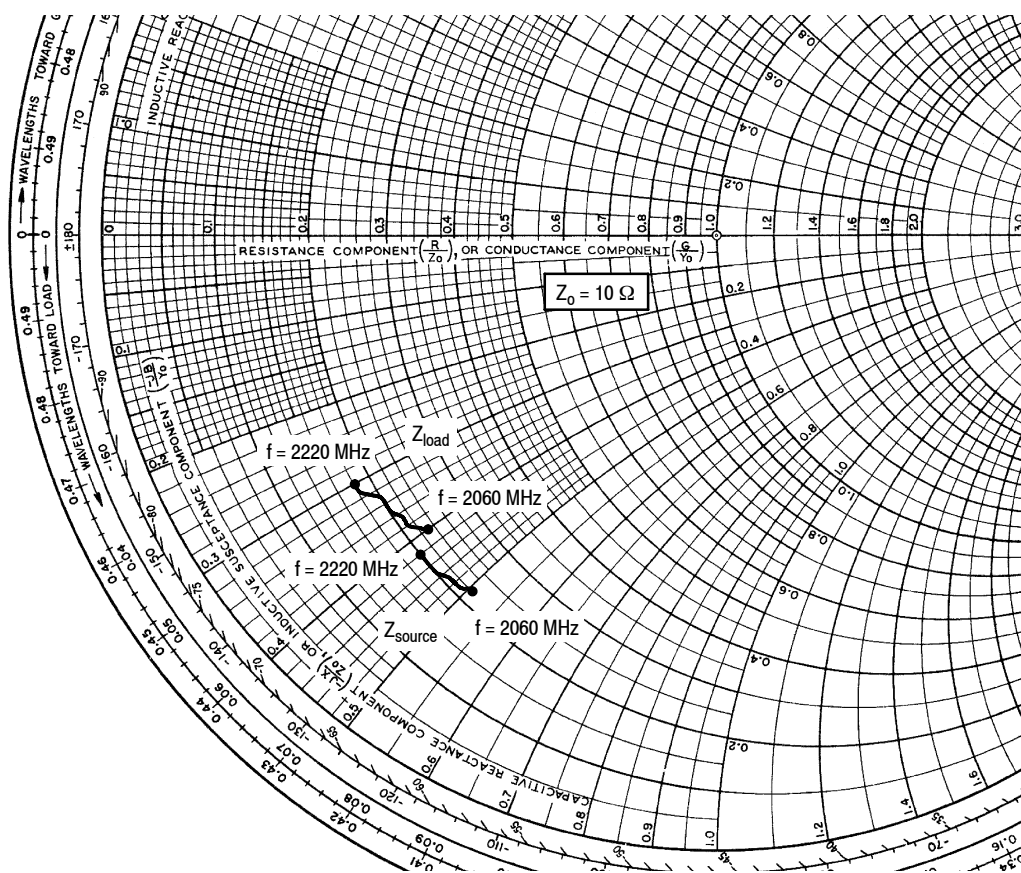


Figure 14. Single-Carrier W-CDMA Spectrum





$V_{DD} = 28 \text{ Vdc}$ ,  $I_{DQ} = 1100 \text{ mA}$ ,  $P_{out} = 33 \text{ W Avg.}$

f MHz	$Z_{source}$ $\Omega$	$Z_{load}$ $\Omega$
2060	2.2 - j5.1	2.3 - j4.0
2080	2.2 - j5.0	2.2 - j3.9
2100	2.1 - j4.9	2.1 - j3.8
2120	2.1 - j4.8	2.1 - j3.7
2140	2.1 - j4.7	2.0 - j3.5
2160	2.0 - j4.5	2.0 - j3.4
2180	2.0 - j4.4	2.0 - j3.3
2200	2.0 - j4.3	1.8 - j3.1
2220	2.0 - j4.2	1.8 - j3.0

$Z_{source}$  = Test circuit impedance as measured from gate to ground.

$Z_{load}$  = Test circuit impedance as measured from drain to ground.

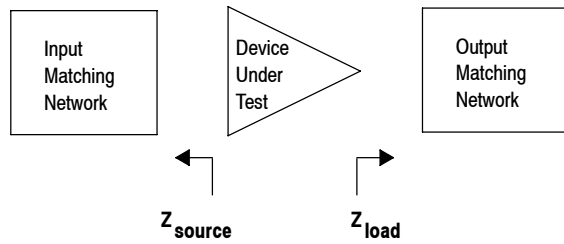
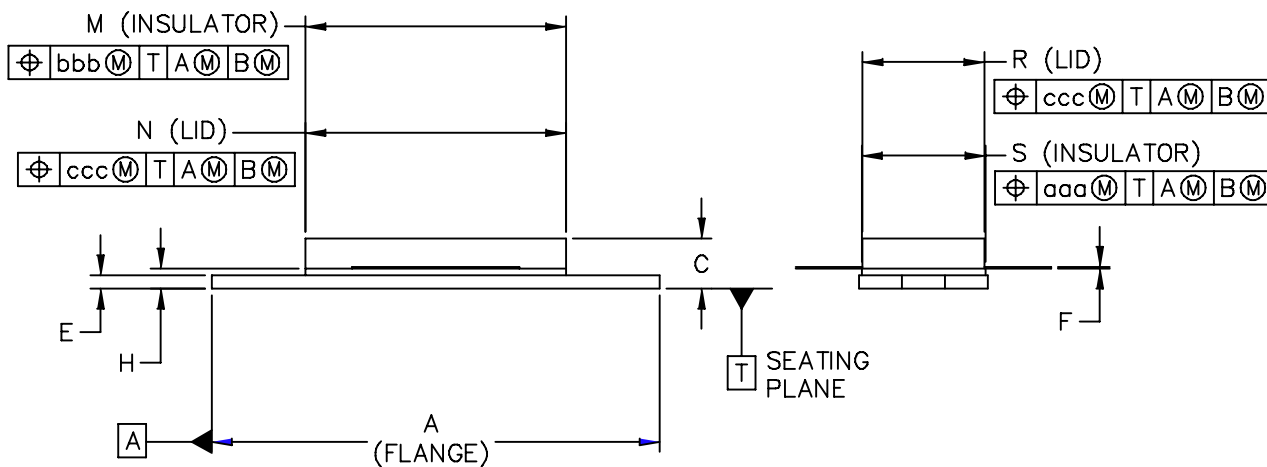
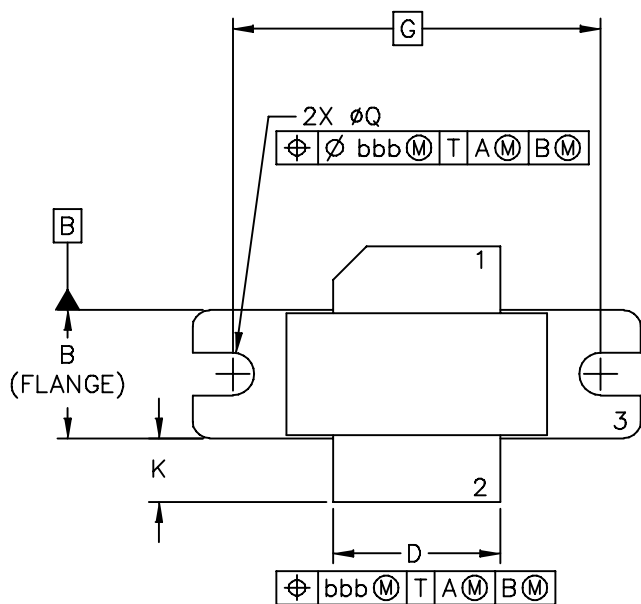


Figure 15. Series Equivalent Source and Load Impedance

PACKAGE DIMENSIONS



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	CASE NUMBER: 465-06		31 MAR 2005
	STANDARD: NON-JEDEC		

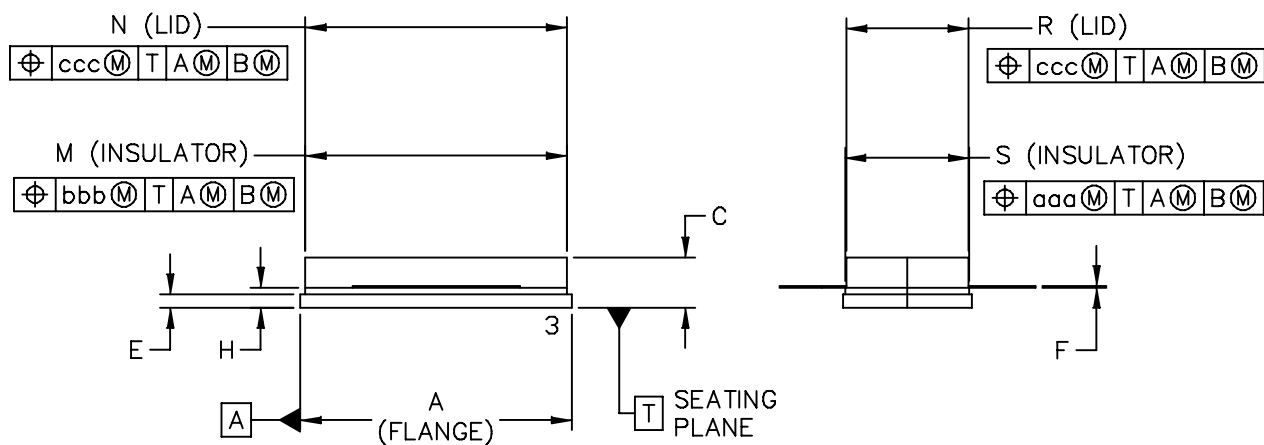
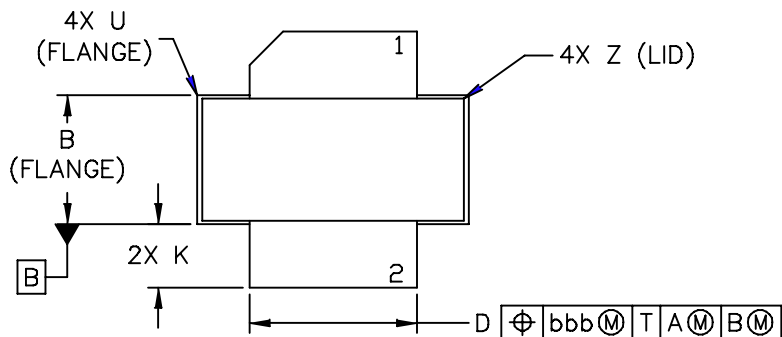
NOTES:

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2. CONTROLLING DIMENSION: INCH.
3. DELETED
4. DIMENSION H IS MEASURED .030 (.762) AWAY FROM PACKAGE BODY.

STYLE 1:

- PIN 1. DRAIN  
 2. GATE  
 3. SOURCE

DIM	INCH		MILLIMETER		DIM	INCH		MILLIMETER	
	MIN	MAX	MIN	MAX		MIN	MAX	MIN	MAX
A	1.335	1.345	33.91	34.16	R	.365	.375	9.27	9.53
B	.380	.390	9.65	9.91	S	.365	.375	9.27	9.52
C	.125	.170	3.18	4.32	aaa	—	.005	—	0.127
D	.495	.505	12.57	12.83	bbb	—	.010	—	0.254
E	.035	.045	0.89	1.14	ccc	—	.015	—	0.381
F	.003	.006	0.08	0.15	—	—	—	—	—
G	1.100 BSC		27.94 BSC		—	—	—	—	—
H	.057	.067	1.45	1.7	—	—	—	—	—
K	.170	.210	4.32	5.33	—	—	—	—	—
M	.774	.786	19.66	19.96	—	—	—	—	—
N	.772	.788	19.6	20	—	—	—	—	—
Q	∅.118	∅.138	∅3	∅3.51	—	—	—	—	—
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STYLE 1:

- PIN 1. DRAIN
2. GATE
3. SOURCE

DIM	INCH		MILLIMETER		DIM	INCH		MILLIMETER	
	MIN	MAX	MIN	MAX		MIN	MAX	MIN	MAX
A	.805	-.815	20.45	20.7	U	-.040	-	-	1.02
B	.380	-.390	9.65	9.91	Z	-.030	-	-	0.76
C	.125	-.170	3.18	4.32	aaa	-.005	-	-	0.127
D	.495	-.505	12.57	12.83	bbb	-.010	-	-	0.254
E	.035	-.045	0.89	1.14	ccc	-.015	-	-	0.381
F	.003	-.006	0.08	0.15	-	-	-	-	-
H	.057	-.067	1.45	1.7	-	-	-	-	-
K	.170	-.210	4.32	5.33	-	-	-	-	-
M	.774	-.786	19.61	20.02	-	-	-	-	-
N	.772	-.788	19.61	20.02	-	-	-	-	-
R	.365	-.375	9.27	9.53	-	-	-	-	-
S	.365	-.375	9.27	9.52	-	-	-	-	-

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		CASE NUMBER: 465A-06		31 MAR 2005	
		STANDARD: NON-JEDEC			

## PRODUCT DOCUMENTATION AND SOFTWARE

Refer to the following documents and software to aid your design process.

### Application Notes

- AN1955: Thermal Measurement Methodology of RF Power Amplifiers

### Engineering Bulletins

- EB212: Using Data Sheet Impedances for RF LDMOS Devices

### Software

- Electromigration MTTF Calculator
- RF High Power Model

For Software, do a Part Number search at <http://www.freescale.com>, and select the “Part Number” link. Go to the Software & Tools tab on the part’s Product Summary page to download the respective tool.

## REVISION HISTORY

The following table summarizes revisions to this document.

Revision	Date	Description
0	Sept. 2007	<ul style="list-style-type: none"> <li>• Initial Release of Data Sheet</li> </ul>
1	July 2008	<ul style="list-style-type: none"> <li>• Added Input Signal in front of PAR for consistency throughout data sheet p. 2, 6, 7, 8</li> <li>• Corrected Table 4, Typical Performances, Output Power Variation over Temperature value from 0.276 to 0.028, p. 3</li> <li>• Updated Fig. 14, CCDF W-CDMA 3GPP, Test Model 1, 64 DPCH, 50% Clipping, Single-Carrier Test Signal, to better represent production test signal, p. 8</li> </ul>
2	Mar. 2011	<ul style="list-style-type: none"> <li>• Modified data sheet to reflect RF Test Reduction described in Product and Process Change Notification number, PCN13628, p. 1, 2</li> <li>• Fig. 13, MTTF versus Junction Temperature removed, p. 8. Refer to the device’s MTTF Calculator available at <a href="http://freescale.com/RFpower">freescale.com/RFpower</a>. Go to Design Resources &gt; Software and Tools.</li> <li>• Fig. 14, CCDF W-CDMA IQ Magnitude Clipping, Single-Carrier Test Signal and Fig. 15, Single-Carrier W-CDMA Spectrum updated to show the undistorted input test signal, p. 8 (renumbered as Figs. 13 and 14 respectively after Fig. 13 removed)</li> <li>• Added Electromigration MTTF Calculator and RF High Power Model availability to Product Software, p. 14</li> </ul>

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